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First record of a male-male aggressive interaction in the golden Alpine salamander *Salamandra atra aurorae* (Caudata, Salamandridae)

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Abstract

The golden Alpine salamander *Salamandra atra aurorae* Trevisan, 1982 is an endemic subspecies found in Sette Comuni and Vezzena plateau in Veneto, Italy. We describe an aggressive interaction between two males which fought for four minutes, trying to go on top of each other and rubbing their chin on the antagonist's head. This is the first documented case of aggressive behaviour in *Salamandra atra aurorae*.

Key Words

Amphibians, behaviour, ecology, male-male interaction

It is important to understand the behavioural patterns that allow amphibians to exploit their terrestrial habitats so we can plan proper management actions and enhance conservation policies. Intraspecific interactions recorded on members of the genus *Salamandra* in terrestrial environments show a relatively wide range of sexual and territorial behaviours, which, apart from mating, include homing, site fidelity, displaying postures to protect territories and detect conspecifics (Werner et al. 2014; Manenti et al. 2017; Di Nicola et al. 2022).

Several male-male interactions have been documented, but mostly in the grey literature. Although they are difficult to interpret because they could be linked to territoriality, mating competition, mistaken mating attempts or sex recognition (Guex and Grossenbacher 2004; Di Nicola et al. 2022), such observations are worth reporting on as they increase the understanding of salamanders' behavioural and ecological requirements. A recent review showed that male-male interactions have been reported for *S. algira*, *S. lanzai* and several subspecies of *S. salamandra* (Di Nicola et al. 2022). Although also male-male interactions for *S. atra atra* are known (Di Nicola et al. 2022), no records for the highly threatened golden Alpine salamander *Salamandra atra aurorae* Trevisan, 1982 exist so far.

Salamandra atra aurorae is endemic to a narrow area ranging from Sette Comuni and Vezzena plateau (Romanazzi and Bonato 2014) in Veneto region (north-east Italy). It can be found mostly in mixed woods with prevalence of beech and white fir, but there are populations in woods with prevalence of spruce and shrubbed meadow (Bonato and Fracasso 2003). If the environment is suitable the golden Alpine salamander can reach high abundances. For example, Bonato and Fracasso (2003) reported a density up to 475 individuals/ha with a sex-ratio of 1:1 and home range of only a few square meters. In the present note we report the first documented case of a male-male aggressive interaction in the golden Alpine salamander.

The observation was made on 4 June 2022, in Bosco del Dosso, near Asiago (Province of Vicenza), the type

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locality of the golden Alpine salamander (Bonato and Grossenbacher 2000), while making a survey focused on the colouration of *S. a. aurorae*. The survey started at 6.45 am, the temperature was 14 °C and the relative humidity was 76%, measured with a Walfront HT-86 Humidity meter (resolution of 0.01% rh, 0.01 °C). At 7.00 am we found two individuals fighting near a white fir. The two salamanders had a highly visible swollen cloaca, a distinctive male characteristic, and unique dorsal patterns that made them recognizable throughout the duration of the interaction. The first salamander, hereafter 'sal1', had a heavy golden colouration on the back, head and limbs; almost all of its dorsal pattern was gold. In contrast, the second one, hereafter 'sal2', had a golden colouration only in the central part of the back, the first part of the limbs and on the head.

The whole interaction was filmed using a Canon EOS 5D Mark III, mounting a 24–70 mm f/2.8 L USM lens. Immediately after spotting the two males, we started recording, capturing four videos of 47, 116, 66 and 5 seconds each for a total of little less than 4 minutes. The videos were cut and merged in order to create a single movie (accessible at https://youtu.be/sVpBYo-E_y0) without change of focus, adjustment of the camera and movements of the operator.

At the beginning of the video (Fig. 1A) sal1 was on top of sal2 trying to rub its chin on the rival's head. After a brief stop sal1 went on trying to grab the competitor's forelimbs and to rub its chin on the opponent's head. During this time sal2 was moving, trying to escape from the rival.

After a quick interruption, during which sal1 seemed to leave the opponent, sal1 turned around and resumed the attack towards sal2 by climbing on top of him and rubbing its chin on the head of sal2. Also this time sal2 was moving, and this was effective in making the opponent fall, even if sal1 was able to quickly recover and get back on top. A few moments later sal2 managed to free itself from the hold of sal1, and sal2 was able to grasp the opponent's forelimbs after getting on top of sal1 using both anterior and posterior legs (Fig. 1B).

After sal1 was able to escape briefly, sal2 continued its attack which was made easier by sal1 being completely still. Even if sal2 was not able to completely get on top of sal1, the head rubbing was very intense since sal2 was in a good position to firmly use its legs to sustain the weight. After some time sal1 escaped the grasp of sal2, which

Figure 1. Stages in the encounter of two male salamanders. **A.** Start of the interaction: sal1 climbing on top of sal2; **B.** Roles are inverted: sal2 is now on top of sal1; **C.** The interaction has ended.

immediately stopped its chase: the two salamanders stayed near each other (30 cm apart) for about one minute (Fig. 1C), after which the two salamanders began to move in opposite directions. This led us to assume that the interaction was over. Only at this point sal2 was collected: it had a total length of 12.14 cm and weighed 11 g. The other individual was not collected, but had a similar size.

The sequence of behaviours displayed by the two males is similar to that reported in the other species of the genus *Salamandra* (Di Nicola et al. 2022) and in several North American salamanders, which, in addition to mounting attempts, forelimb grasping and snout-rubbing behaviours, also display more aggressive behaviours such as bite, bite-hold, and cannibalism as the ultimate aggressive response (Staub 1993; Camp and Lee 1996; Davis 2002; Deitloff et al. 2014). The biting behaviour was associated with *Salamandra salamandra* by Verrell (1989) but without mention of any occurrence. As of today, more research is needed to confirm this behaviour in the genus *Salamandra*. It can now be confirmed that aggressive male-male interactions are present in the golden Alpine salamander. Considering the rarity of information about this behaviour in this species, and more generally in the genus *Salamandra*, it is important to address the factors that enhance the probability of male-male aggressive interactions, to assess the frequency of these interactions and their biological meaning in terms of advantages for mating and trophic resources access.

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